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Thermal ecology of Stejneger's robber frog *Craugastor stejnegerianus* (Anura: Craugastoridae) in the tropical dry forest of Parque Nacional Guanacaste, Costa Rica

Ecología térmica de la rana de hojarasca de Stejnegers *Craugastor stejnegerianus* (Anura: Craugastoridae) en el bosque seco tropical del Parque Nacional Guanacaste, Costa Rica

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Abstract

Introduction: In a climate changing world it is indispensable to know the behavioral and physiological responses of amphibians to environmental temperature variation. Even so, thermal ecology is unknown for many species, including *Craugastor stejnegerianus*. Therefore, it is important to describe the patterns and mechanisms that influence body temperature and if these obey to the environmental temperature or to thermoregulation actions. **Objective:** The aim of this paper is to describe the relationship between environmental and substrate temperatures, as well as the behavior and substrate use with the body temperature of *C. stejnegerianus*. **Methodology:** The body temperature of individuals of *C. stejnegerianus* was monitored 13.4 h, along with measures of environmental temperature, substrate use and behavior observations. **Results:** the results obtained were that the body temperature is related to the substrate temperature but it does not depend on the variations of environmental temperature nor behavior or substrate use. **Conclusion:** Based in our findings we propose that the body temperature variation of this frog is circumstantial and there is not behavior of thermoregulation.

Keywords: Leaf-litter frog, Maritza Biological Station, Microhabitat, Thermoregulation.

Resumen

Introducción: En un mundo de clima cambiante, es indispensable conocer las respuestas fisiológicas y comportamentales de los anfibios a la variación ambiental de temperatura. Sin embargo, la ecología térmica es desconocida para muchas especies, incluyendo a *Craugastor stejnegerianus*. Por lo tanto, es importante describir los patrones y mecanismos que influyen sobre la temperatura corporal o sobre acciones de termorregulación. **Objetivo:** Se busca describir las relaciones de la temperatura ambiental y de sustrato, así como del comportamiento y uso de sustratos con la temperatura corporal de *C. stejnegerianus*. **Metodología:** La temperatura corporal de individuos de *C. stejnegerianus* fue monitoreada 13.4 h, junto con medidas de la temperatura ambiental, humedad relativa, uso de sustratos y observaciones de comportamiento. **Resultados:** Se obtuvo que la temperatura corporal está relacionada con la temperatura del sustrato y esto no depende de las variaciones de temperatura ambiental, ni del comportamiento o uso de sustrato. **Conclusión:** De acuerdo con los hallazgos, se propone que las variaciones de la temperatura corporal de esta rana son circunstanciales y no hay comportamientos de termorregulación.

Palabras clave: Estación Biológica Maritza, Microhábitat, Rana de hojarasca, Termorregulación.

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Introduction

Amphibians are ectothermic animals which depend on environmental temperature to develop its physiological functions and behavioral activities (Köhler *et al.* 2011). The body temperature of these organisms is closely related with environmental temperature; nevertheless, some species have a complex thermoregulation behavior (Rowley and Alford 2009). Thermoregulation in amphibians is based on direct exposure to sunlight and absorption of solar radiation (heliothermia) (Brattstrom 1979). The thermoregulation behavior in amphibians determines, most of the times, the use of microhabitats (tigmothermia) and the activity patterns of the species (Brattstrom 1979, Navas 1996, Navas *et al*. 2013).

In tropical amphibians the body temperature is influenced by natural history and the ecology of the species (Navas *et al*. 2013). Besides, it has been registered that, in some cases, body temperature is closely related to substrate temperature, in spite of elevation differences, biome and species habits (Navas 1996, Navas *et al*. 2013). This relationship responds to thermoregulation behavior to face environmental conditions. In this paper, we classify the temperatures relation in: a) obeys to thermoregulation actions and b) circumstantial relation. Response "a" can be seen in stenothermal frogs exposed to wide ranges of environmental temperature or in eurythermal frogs when its activities are determined by body temperature (Navas 1996). On the contrary, response "b" is shown when frogs are exposed to less variable environmental conditions.

The knowledge about thermic ecology is not existent or scarce for many species of amphibians. This animals are especially sensitive to long-term global climate change because warming temperatures and altered hydrologic cycles are expected to increase thermal stress, affect disease susceptibility, desiccate breeding habitats, reduce availability of critical microhabitats, and alter foraging behavior and efficiency (Ryan *et al*. 2014). Therefore it is important to describe the mechanisms and patterns that regulate their body temperature, and if these involve thermoregulation behavior or are circumstantial. The aim of this paper is to describe the body temperature variation in Stejneger's Robber Frog *Craugastor stejnegerianus* during its nocturnal activity in the dry tropical forest of Costa Rica.

The Stejneger's Robber Frog *C. stejnegerianus* (Figure 1) can be found in humid lowlands and premontane slopes on the Pacific versant of western Panama and Costa Rica (Solís *et al.* 2008). This is a diurnal leaf litter species found in humid lowland and dry forest, and may be present in different vegetation cover types such as secondary forest, plantations and pastureland. It is an important predator in the leaf litter environment and plays a crucial role in nutrient cycling, energy flow, and carbon storage of forest ecosystems (Ryan *et al*. 2015). This species breeds by direct development (Solís *et al*. 2008).

Study area. The Maritza Biological Station (10°57'N, 085°29'W; 570 masl) is located in the Pacific slope of the Orosí Volcano, in Guanacaste

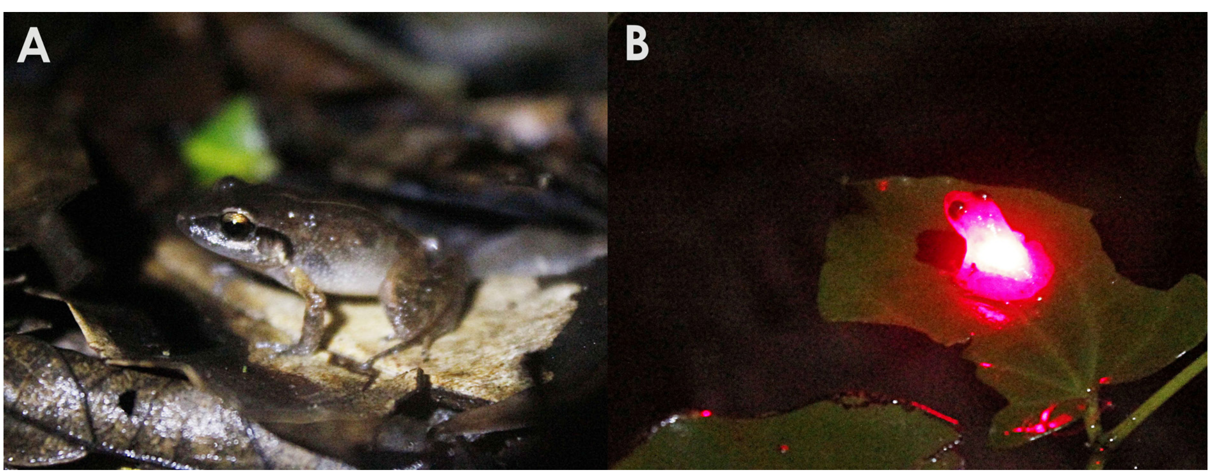

Figure 1. The Stejneger's Robber Frog *Craugastor stejnegerianus* at Maritza Biological Station, Costa Rica. A) Individual found active at night, B) and individual being monitored with an infra-red thermometer of 0.1°C precision.

National Park, Costa Rica (Figure 2). The mean annual precipitation is 3000 mm, and the temperature varies among 19-28 °C (ACG 2013). The station is composed by tropical dry forest in transition with rainforest. The study area corresponds to a site in early regeneration or secondary forest (10°57'18.4''N, 085°29'33.4''W; 583 masl).

Methodology

The thermal ecology of 7 individuals of *C. stejnegerianus* was studied between the 23 and 24 of July 2013. Even when this species is considered diurnal, it was found completely active at night (Figure 1A). The effort of nocturnal monitoring was 13.4 h. The individuals were monitored in an area of 36 m^2. Every 20 minutes several variables were recorded for each individual: 1) substrate used, 2) behavior, 3) body temperature, 4) microhabitat temperature, and 5) environmental temperature.

The microhabitats were categorized as: leaf litter (individuals found in the leaf litter or in the ground), leaf (individuals located on leaf or stem of standing plants). The behavior was classified as "jump", "call" and "perching" for non-active individuals.

The body temperature was registered telemetrically with an infra-red thermometer of 0.1°C precision, located on the back of the frog at a minimum distance of 15 cm, which allowed a temperature lecture of 2 cm of diameter (Figure 1B). The same equipment was used to measure the substrate temperature, taken from the place where the frog was found. The environmental temperature was obtained with a thermohigrometer of 0.1°C precision, placed 0.5 m above the ground.

Because the data obtained in this study does not meet the assumptions for statistical tests, data were analyzed descriptively. Environmental, substrate, and body temperature were plotted to see if these were related. In addition, box-and-whisker plots were used for comparison samples between substrate and activity; herein notches were drawn in order to regard differences among data (Chambers *et al*. 1983). The box-and-whisker plots construction requires a sample of at least 5 by comparison (Krzywinski and Altman 2014). This is adequate for the sample size in the present study. The graphics were developed in R language with ggplot2 package (Wickham 2009)

Results

A total of 37 records of body temperature of *C. stejnegerianus* was obtained. The mean body temperature of the frogs was 21.4±0.66°C (mean±SD, range: 20.1-22.7°C), the mean microhabitat temperature was 21.58±0.67°C (20-22°C) and the mean environmental temperature was 22.32±0.57°C (21.2-

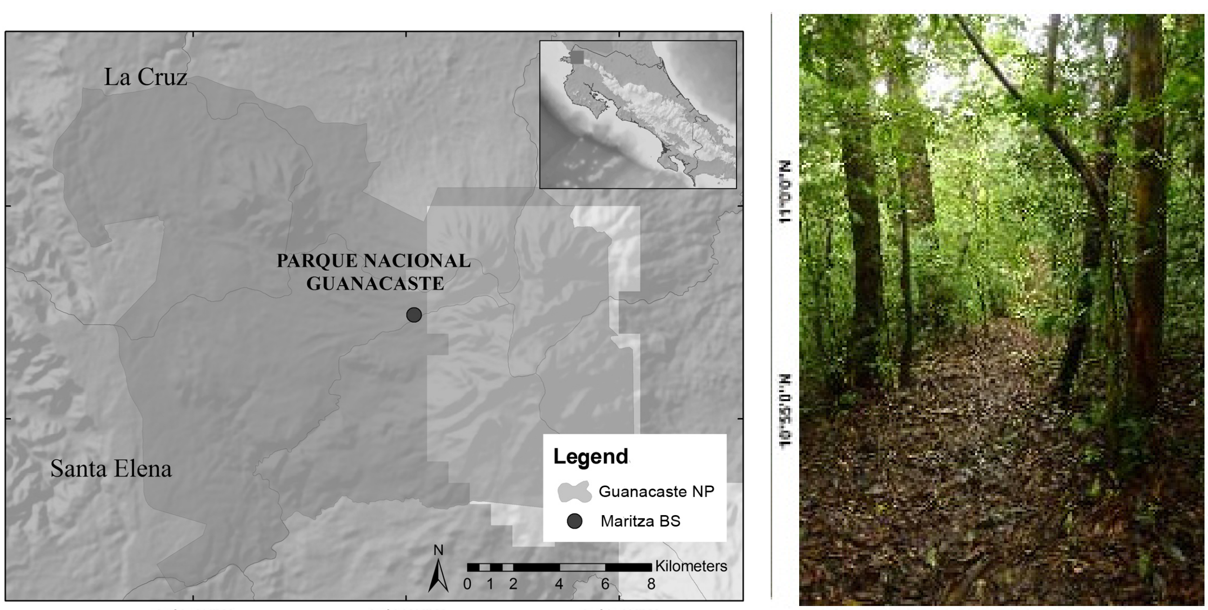

Figure 2. Study area at Maritza Biological Station (left) and habitat where *Craugastor stejnegerianus* was found (Photography: Talía Zamboni), Guanacaste National Park, Costa Rica.

23.4°C). The body temperature does not appear to be related to environmental temperature oscillations (Figure 3A), but it is related to microhabitat temperature (Figure 3B).

It appears that the body temperature of frogs located in leaves is higher and less variable compared to the frogs found on leaf litter (Figure 4A). Compared with the activity of the frogs it is observed that the body temperature is lower in those frogs in call activity, nevertheless the temperature is more variable during this activity according to data dispersion (Figure 4B). However, according to the overlap of notches in the box-and-whisker plots, there is not difference among body temperature neither by substrate nor by activity. Range in body temperature, though closely related to substrate temperature (Figure 3A, B), does not depend on substrate use or activity (Figure 4A, B).

Discussion

Body temperature variation of *C. stejnegerianus* coincides with the estimated for anurans of tropical dry forest at moderate elevations (700-900 masl) in Colombia (Navas *et al.* 2013). Moreover, its high relationship with substrate temperature agrees with those found for other species of the family Craugastoridae with terrestrial and nocturnal habits (Navas *et al*. 2013). Taking this into account, thermal ecology

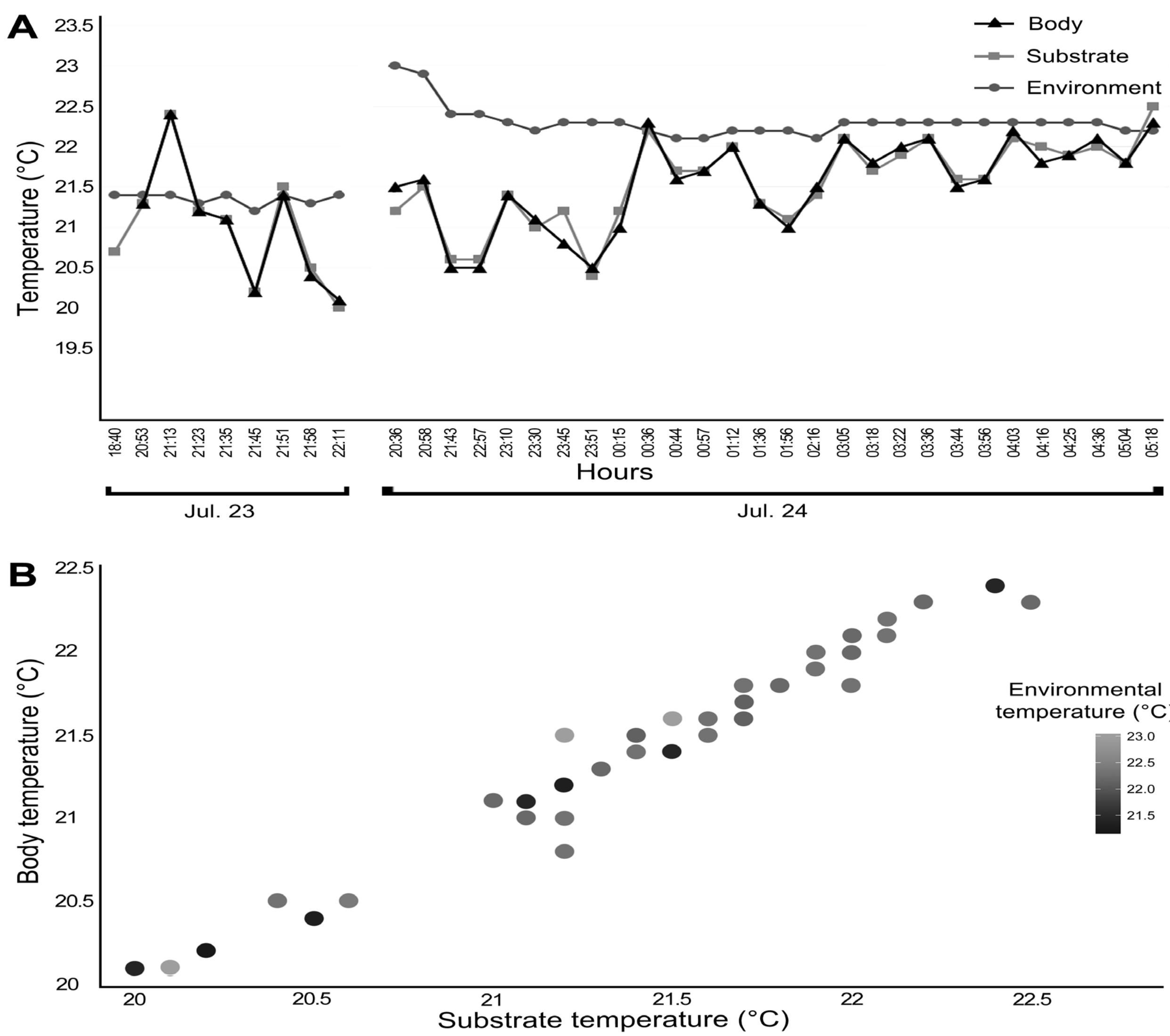

Figure 3. Relation between environmental and substrate temperature with body temperature of *Craugastor stejnegerianus* at the Maritza Biological Station, Costa Rica.

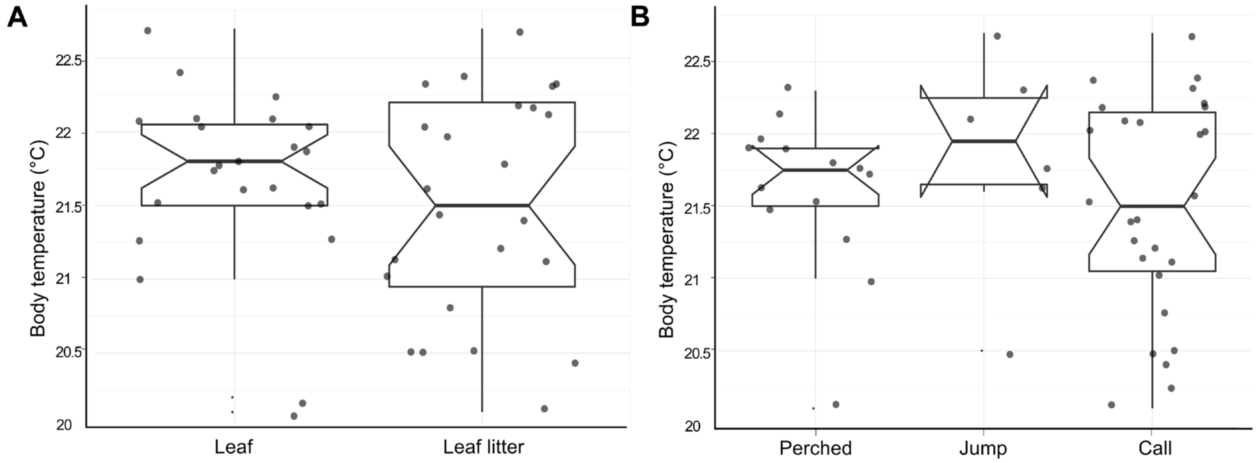

Figure 4. Box-and-whisker plots of body temperature with relation of substrate use (A) and activity (B) of *Craugastor stejnegerianus* at the Maritza Biological Station, Costa Rica.

of *C. stejnegerianus* seems usual and obeys to the general pattern presented by other tropical anurans of similar habits.

It has been reported that amphibians do not present thermoregulation, therefore, its body temperature is influenced mainly by the environmental temperature (Rowley and Alford 2009). Nevertheless, this study shows that body temperature was not related to environmental temperature overall, and the species did not have evident thermoregulation behavior (Brattstrom 1979, Navas 1996, Navas *et al*. 2013). The results point out that the body temperature of *C. stejnegerianus* is related circumstantially to the substrate temperature, regardless of the environmental temperature.

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Literature cited

ACG (Área de Conservación Guanacaste). *Estación Biológica Maritza.* (Online). 2010. (Accessed on August 12, 2013). San José: Centro de Investigación del Bosque Tropical Seco y Estaciones Biológicas. URL http://www.acguanacaste.ac.cr/1997/ecodesarrollo/ecoturismo/est_biol.html>

Brattstrom BH. 1979. Amphibian temperature regulation studies in the field and in the laboratory. *Am Zool. 19:* 345-56.

Chambers JM, Cleveland WS, Kleiner B, Tukey PA. 1983. *Comparing data distributions. In graphical methods for data analysis.* Belmont: Wadsworth International Group.

Köhler A, Sadowska J, Olszewska J, Trzeciak P, Berger-Tal O, Tracy CR. 2011. Staying warm or moist? Operative temperature and thermal preferences of common frogs (*Rana temporaria*), and effects pn locomotion. *Herpetol J. 21:* 17-26.

Krzywinski M, Altman N. 2014. Points of significance: Visualizing samples with box plots. *Nat Meth. 11:* 119-20.

Navas CA. 1996. Implications of microhabitat selection and patterns of activity on the thermal ecology of high elevation neotropical anurans. *Oecologia*. *108:* 617-26.

Navas CA, Carvajalino-Fernández JM, Saboyá-Acosta LP, Rueda-Solano LA, Carvajalino-Fernández MA. 2013. The body temperature of active amphibians along a tropical elevation gradient: patterns of mean and variance and inference from environmental data. *Funct Ecol*. Online version: 1-10.

Rowley JJL, Alford RA. 2009. Models in field studies of temperature and moisture. *In:* Dodd CK (ed.). *Amphibian ecology and conservation.* Oxford: Oxford University Press.

Ryan MJ, Scott NJ, Cook JA, Willink B, Chaves G, Bolaños F, *et al.* 2015. Too wet for frogs: changes in a tropical leaf litter community coincide with La Niña. *Ecosphere. 6 (1):* 1-10.

Ryan MJ, Fuller MM, Scott NJ, Cook JA, Poe1 S, Willink B, *et al.* 2014. Individualistic population responses of five frog species in two changing tropical environments over time. *Plos One. 9 (5):* 1-8.

Solís F, Ibáñez R, Chaves G, Savage J, Jaramillo C, Fuenmayor Q, *et al.* 2008. *Craugastor stejnegerianus*. The IUCN Red List of Threatened Species (Online). Version 2014.3. (Access on 01 February 2015) URL: http:// www.iucnredlist.org

Wickham, H. 2009. *Ggplot2: elegant graphics for fata analysis*. New York: Springer.